UNIVERSITI PUTRA MALAYSIA

ACOUSTIC PROPERTIES OF LOW DENSITY OIL PALM (ELAEIS GUINEENSIS JACQ) FIBREBOARD

SEMSOLBAHRI BOKHARI

ACOUSTIC PROPERTIES OF LOW DENSITY OIL PALM (*ELAEIS GUINEENSIS* JACQ) FIBREBOARD

By

SEMSOLBAHRI BOKHARI

Thesis Submitted in Fulfilment of the Requirements for the Degree of Master Science in the Faculty of Forestry
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Dedicated to my loving parents, brothers, sisters,
and my special friend, Mus. M

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master Science

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Chairman : Mohd. Ariff Jamaludin, Ph.D.

Faculty : Forestry

An ultrasonic test was carried out to determine the acoustic properties of low density oil palm fibreboard. The main objective of this study was to investigate the suitability of using oil palm empty fruit bunches (EFB) as partial replacement for the acoustic materials in audio room.

The board was manufactured by using rubberwood (*Hevea bracilliensis*) and oil palm (*Elaeis guineensis, Jacq*). The rubberwood was used as the control. Three levels of board density and five thicknesses were used to investigate the relationship of acoustic parameters (wave velocity and attenuation coefficient) to these independent variables. In

addition, this study consisted of two sub-studies; (i) the effect of resin content on the acoustic properties, and (ii) the trend of pulse velocity travelling through the boards of different thicknesses.

The result showed that the acoustic properties of oil palm boards were significantly affected by a variation in board densities and thicknesses, as well as resin content. On the other hand, it was found that the velocity of pulse was influenced by the variation in the resin content, thickness and density of the boards.

The pulse velocity, which travels through the EFB, was similar to that of rubberwood boards, suggesting that the acoustic properties of EFB were in the same class as that of rubberwood. The board with 12 mm thickness was found to be able to absorb more pulse wave than the board of other thicknesses for each type of board density.

Based on the result, the low density oil palm fibreboard was suitable to be used as a core layer for building a wall in audio room. However, it needs further improvement on it's design and structure to have a better performance as the absorbent materials. This study also found that the ultrasonic test could be a good non-destructive test method to assess the acoustic properties.

Abstrak thesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains.

SIFAT AKUSTIK PAPAN GENTIAN BERKETUMPATAN RENDAH DARIPADA TANDAN KELAPA SAWIT (*ELAIS GUINEENSIS, JACQ*)

Oleh

SEMSOLBAHRI BOKHARI

Mac 2000

Pengerusi: Mohd. Ariff Jamaludin, Ph.D.

Fakulti: Perhutanan

Kajian ini telah menggunakan ujian ultrasonik bagi menentukan sifat bunyi papan gentian berketumpatan rendah. Objektif utama kajian ini dijalankan adalah untuk mengenalpasti kesesuaian penggunaan papan gentian daripada tandan kelapa sawit (EFB) sebagai pengganti separa untuk bahan akustik di dalam bilik audio.

Papan gentian tersebut telah dihasilkan daripada dua jenis bahan mentah iaitu gentian kayu getah *(Hevea bracilliensis)* dan gentian kelapa sawit (*Elaeis guineensis, Jacq).* Papan gentian daripada kayu getah dijadikan sebagai kawalan dalam kajian ini. Tiga jenis ketumpatan papan dan lima jenis ketebalan yang berlainan telah dihasilkan bagi setiap jenis bahan tersebut untuk memahami hubungan antara variasi ini dengan parameter-parameter sifat akustik bahan (halaju dan

amplitud gelombang bunyi). Kajian ini mengandungi dua lagi sub-kajian iaitu (i) kesan perekat yang digunakan ke atas sifat akustik dan (ii) sifat halaju gelombang bunyi terhadap variasi ketebalan papan gentian tersebut.

Hasil kajian ini mendapati bahawa, amplitud tekanan bunyi (attenuation coefficient) telah dipengaruhi oleh ketumpatan dan ketebalan papan. Manakala, halaju nadi (pulse velocities) pula telah dipengaruhi oleh variasi kandungan bahan perekat, ketebalan dan ketumpatan papan gentian ini.

Halaju nadi bagi papan gentian daripada kelapa sawit adalah sama dengan halaju nadi bagi papan gentian getah. Ini bermakna bahawa, sifat akustik bagi gentian kelapa sawit berada di dalam kelas yang sama dengan gentian kayu. Keputusan kajian juga menunjukkan bahawa papan gentian berketebalan 12 mm mampu menyerap lebih banyak gelombang bunyi berbanding dengan papan gentian dari ketebalan yang lain.

Berdasarkan kepada keputusan dalam kajian ini, papan gentian berketumpatan rendah daripada kelapa sawit adalah sesuai untuk dijadikan bahan penebat bunyi pada dinding sebuah bilik audio. Namun, ia memerlukan sedikit peningkatan dari segi stuktur dan reka bentuk untuk dijadikan bahan penebat bunyi yang lebih baik. Kajian ini juga mendapati bahawa ujian ultrasonik amat sesuai digunakan dalam menentukan sifat akustik dan juga sifat kekenyalan bahan.

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I certify that an Examination Committee met on 29 March 2000 to conduct the final examination of Semsolbahri Bokhari on his Master of Science thesis entitled "Acoustic Properties of Low Density Oil Palm (*Elaeis guineensis,* Jacq) Fibreboard" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of The Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my work except for quotations and citations which have been duly acknowledged. I also declare that this thesis has not been previously or concurrently for any other degree at UPM or any other institutions.

Signed

(SEMSOLBAHRI BOKHARI)

Date: 25 May 2000

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LIST OF ABBREVIATIONS

σ	Stress Wave
ρ	Density of Materials
θ	Angel of Sound Source and Reflection
ν	Pulse Velocity
α	Attenuation Coefficient
λ	Distance per Cycle of Pulse Wave
β	Diffraction Angel
ω_r	Instantaneous Energy System
δ	Logarithmic Decrement; Harmonically oscillating System
σ_{n+1}	Amplitudes of Two Consecutive Cycles
f	Frequency Used for Testing
W	Energy Loss per Cycle
Q	Dissipation Factor
N	Newton
Z_i	Sound Impedance
dB	Decibels;
t	Transit time of Pulse
v	Volume
g	Gravity Acceleration
MOE	Modulus of Elasticity
PORIM	Palm Oil Research Institute of Malaysia
MINT	Malaysia institute of Nuclear Technology
PF	Phenol Formaldehyde
TL	Transmission Loss

CHAPTER I

INTRODUCTION

ACOUSTIC PROPERTIES OF WOOD

Wood and oil palm are both cellulosic materials. Thus, the acoustic properties of oil palm fibres (empty fruit bunches, trunk and frond) could be similar to wood. The acoustic properties of wood vary with anatomy, density, moisture content and the temperature of the surrounding atmosphere (Bootle, 1971; Schiewind, 1989). The ability of a material to absorb sound is dependent on its mass. That is, the way it is fixed, and the acoustic properties of the surface of the material (Warnock, 1990; Desh and Dinwodie, 1983; Parkin et al. 1979;) i.e, whether the surface is capable of absorbing or reflecting sound (gluing and surface coating for wood) (Schultz, 1969; Bucur, 1986; Kollmann, 1969).

However, there is no documentation on the acoustic properties of oil palm fibreboard. Thus, this study was carried out to evaluate the acoustic properties of low density oil palm fibreboard, and to compare their acoustic properties to the rubberwood fibreboard.

ULTRASONIC DETERMINATIONS

The ability of ultrasound to measure and monitor micro-structure related properties has been established in the laboratory. Invariably, two of the propagation parameters that are used in the ultrasonic determination of a material are attenuation and sound wave velocity (Serabian, 1986). The two principle causes of attenuation are scattering and absorption. The latter are intrinsic to the particular combination of material and processes under consideration. Absolute quantitative relations are usually unavailable, therefore, empirical material property-ultrasonic parameter correlation based upon qualitative reasoning are sought. According to Vary (1987), velocity measurements are useful for measuring elastic constant, residual stress, and density.

PROBLEM STATEMENT

The acoustic properties of commercial wood species such as rubberwood have been documented in the last few years (Chew et. al. 1981). However, there is no documentation on the acoustic properties of oil palm. Therefore, it is important to document its acoustic properties so that its potential for musical instruments and acoustic building materials can be explored.

In this country, direct method (reverberation room test) could not be used to test the acoustic properties of a material because of the appropriate equipment is not available. Furthermore, the available direct method needs large samples and are very costly. Hence, this study used the indirect method to determine the acoustic properties of low density oil palm fibreboard, which is ULTRASONIC, a non-destructive test (NDT). A direct transmission principle was used to measure the amplitude and transit time of pulse that travel through the samples in order to determine their acoustic properties.

OBJECTIVE

The main objective of this study is to evaluate the acoustic properties of oil palm fibres. And to propose the potential end uses of low density oil palm fibreboard.

The specific objectives of this study were:

1. To identify the factors affecting the acoustic properties of low density oil palm fibreboard.
2. To understand the trend of pulse velocity that travel through various board thicknesses.
3. To compare the acoustic properties of low density oil palm fibreboard to wood fibreboard.

CHAPTER II

LITERATURE REVIEW

ACOUSTIC PROPERTIES OF MATERIAL

Definition of Acoustic

The concept of energy and pressure are essential in understanding the applications of acoustic. Generally, acoustics is the science of sound, which includes its distribution, and absorption of sound wave by materials (Ahmad Khan, 1990; Pierce, 1998). One of the essential features of sound is pressure. The feature that is always associated with sound vibration of materials particles (Porgess, 1977) is known as sound pressure. Pressure is transferred from one vibrating particle to the next, and acoustic pressure always travels through the medium as a wave (Hopper, 1969; Leslie et al. 1985; Michael, 1993; James, 1994).

Room Acoustic

In a room, those for direct listening, natural signals are used and picked up directly by the ear of the listener. The radiation and reception processes take place in the same enclosure; these processes are adjacent in space and time (Nelson, 1973). A principal characteristic of this nature is that the power of the sound source employed in them is comparatively small (Manskovy, 1971) and is confined by the limitation of human voice and musical instrument.

Room acoustic is concerned with sound propagation in enclosures where the sound-conducting medium is bonded on all sides by walls, ceiling, floor and furnishing (Kutruff, 1990; Dunlop, 1980; Pollard, 1977). This boundary usually reflects a certain fraction of the sound pressure impinging onto them. Another fraction of the pressure is absorbed. This latter pressure is extracted from the sound field inside the room either by conservation into heat or by being transmitted to the outside by the walls (James, 1994). The combination of the numerous reflected components and un-reflected wave are responsible for what is known as `the acoustics of a room' and also for the sound field in a room (Kuttruff, 1990).

What is Ultrasound?

`Sound' is due to a stream of `atom' emitted by the sounding body (Lyle, 1978). The speed of this atom after being emitted or propagated are known as velocity of sound then, the number of emitted atom per unit of time is the frequency of sound wave. There are three types of frequencies disturbances; the low disturbances of frequencies (infrasound) which is too low to be heard by human ear. Secondly, is audible sound which is can be heard by human, this sound wave ranging 20 Hz to 20 kHz (Quote: Mohd. Pauzi). Finally, the higher disturbance of frequencies is known as ultrasound, which is too high to be heard by human ear. The frequencies of ultrasound are above 20 kHz (Pierce, 1998).

According to Kuttruff (1991), ultrasound can be thought of as analogous to ultraviolet light in that it characterises region of acoustic phenomena which is not accessible to human perception, because of the high frequencies involved.

An Application of Ultrasound

Any kind of sound in contrast to electromagnetic waves can only be propagated in a material medium. Its velocity is strongly influenced by that medium, and its attenuation depends on the nature of the medium (Alex et al. 1987). Hence, if these quantities are known from a measurement, conclusion can be drawn concerning the physical properties of the medium.

Ultrasonic is a name given to the study and application of ultrasound which is the sound of a pitch too high to be detected by the human ear (frequencies greater that 20 kHz). According to Blitz and Geof